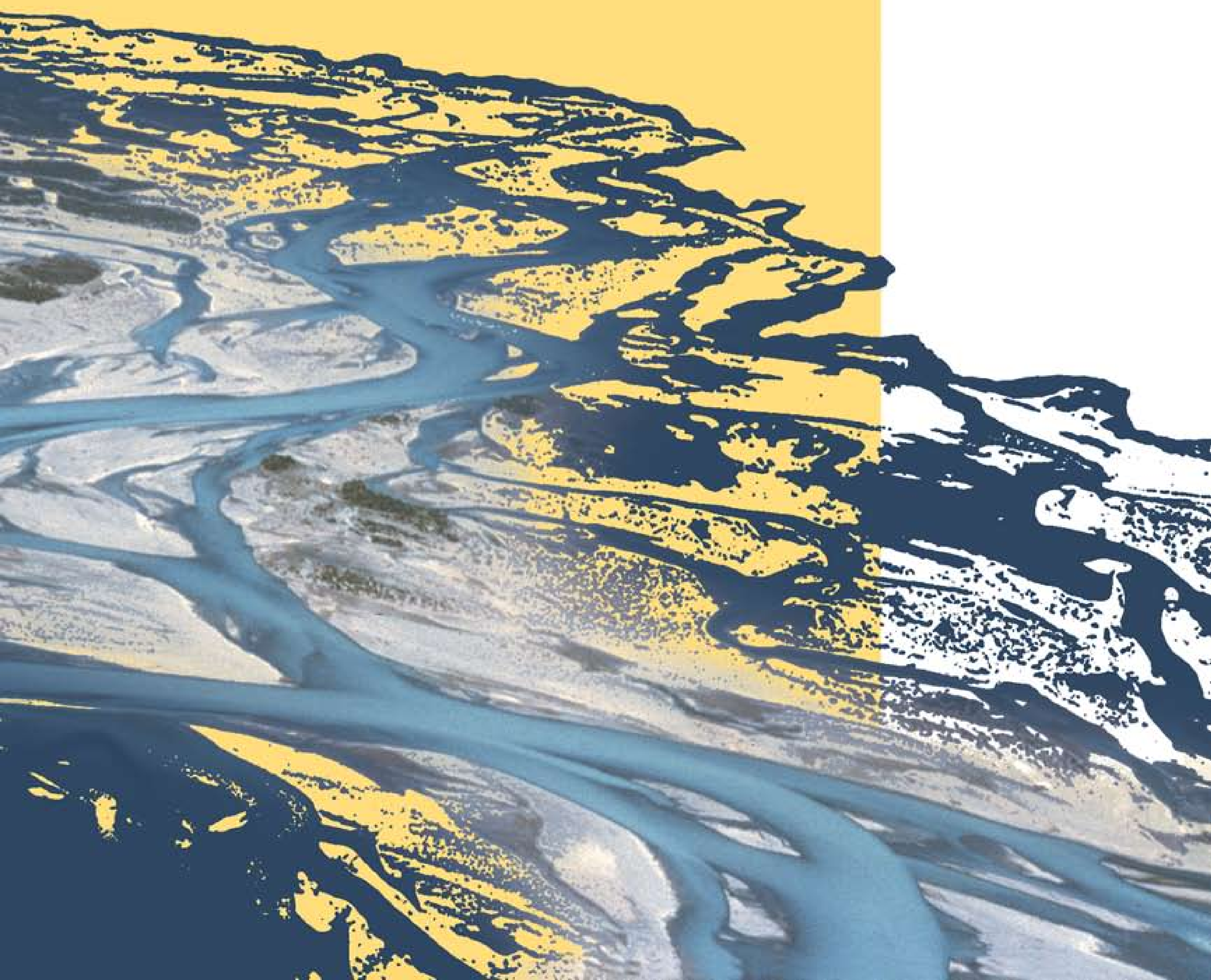
SYSTEM MANUALS

of BASEMENT



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VERSION 2.1

December, 2010

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Commissioned and co-financed by

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Citation Advice

For System Manuals:

Faeh, R, Mueller, R, Rousselot, P, Vetsch, D, Volz, C., Vonwiller, L., Veprek R., Farshi, D 2010. *System Manuals of BASEMENT*, Version 2.1. Laboratory of Hydraulics, Glaciology and Hydrology (VAW). ETH Zurich. Available from <http://www.basement.ethz.ch>. [date of access].

For Website:

BASEMENT – Basic Simulation Environment for Computation of Environmental Flow and Natural Hazard Simulation, 2010. http://www.basement.ethz.ch

For Software:

BASEMENT – Basic Simulation Environment for Computation of Environmental Flow and Natural Hazard Simulation. Version 2.1. © VAW, ETH Zurich, Faeh, R., Mueller, R., Rousselot, P., Vetsch, D., Volz, C., Vonwiller, L., Veprek R., Farshi, D., 2006-2010.

Preface to Versions 1.0 – 1.3

The development of computer programs for solving demanding hydraulic or hydrological problems has an almost thirty-year tradition at VAW. Many projects have been carried out with the application of "home-made" numerical codes and were successfully finished. The according software development and its applications were primarily promoted by the individual initiative of scientific associates of VAW and financed by federal instances or the private sector. Most often, the programs were tailored for a specific application and adapted to fulfil costumer needs. Consequently, the software grew in functionality but with little documentation. Due to limited temporal and personal resources to absolve an according project, a single point of knowledge concerning the details of the software was inevitable in most of the cases.

In 2002, the applied numerics group of VAW was invited by the Swiss federal office for water and geology (BWG, nowadays Swiss Federal Office for the Environment FOEN) to offer for participation in the trans-disciplinary "Rhone-Thur" project. With the idea to build up a new software tool based on the knowledge gained by former numerical codes - while eliminating their shortcomings and expanding their functionality - a proposal was submitted. The bidding being successful a partnership in terms of co-financing was established. By the end of 2002, a newly formed team took up the work to build the so-called "BASic EnvironMENT for simulation of environmental flow and natural hazard simulation – BASEMENT".

From the beginning, the objectives for the new project were ambitious: developing a software system from scratch, containing all the experience of many years as well as state-of-the-art numerics with general applicability and providing the ability to simulate sediment transport. Additionally, professional documentation is a must. As to meet all these demands, a part wise reengineering of existing codes (Floris, 2dmb) has been carried out, while merging it with modern and new numerical approaches. From a software-technical point of view, an object-oriented approach has been chosen, with the aim to provide reusability, reliability, robustness, extensibility and maintainability of the software to be developed.

After four years of designing, implementing and testing, the software system BASEMENT has reached a state to go public. The documentation at hand confirms the invested diligence to create a transparent software system of high quality. The software, in terms of an executable computer program, and its documentation are available free of charge. It can be used by anyone who wants to run numerical simulations of rivers and sediment transport – either for training or for commercial purposes.

The further development of the software tends to new approaches for sediment transport simulation, carried out within the scope of scientific studies on one hand side. On the other hand, effectiveness and composite modelling are the goals. On either side, a reliable software system BASEMENT will have to meet expectations of the practical engineer and the scientist at the same time.

em. Prof. Dr.-Ing. H.-E. Minor
Member of the steering committee of Rhone-Thur Project 2002-2007
Director of VAW, 1998-2008

October, 2006

Preface to Versions 1.4

The work since the first release of the software in October 2006 was exciting and challenging. To go public is paired with interests and demands of users – although user support for the software never was intended. But interchange with users is definitely one of the most crucial factors of successful software development. Feedback from academic or professional users conveys a different point of view and enables the development team to achieve costumer proximity as well as to consolidate experience. Accordingly, the project team tried to meet the demands as effectively as possible. In version 1.3 of BASEMENT, which was released in April 2007, there were some errors fixed, a few new features added and the documentation was completed. Since then, many things have changed: on the personnel, on the project as well as on the software technical level.

In summer 2007 one of our main software developers, Dr. Davood Farshi, left VAW and changed to an international hydraulic consultant. Dr. Farshi supported our team from 2002 to 2007 as a profound numeric specialist and was mainly involved in the development of BASEplane. At his own request, he is still engaged in the development of BASEMENT as external advisor and tester. Dr. Farshi's position in the project team was reoccupied by Christian Volz, an environmental engineer from southern Germany. Mr. Volz has broad experience in numerical modelling as well as object-oriented programming.

On the project level the framework slightly changed. The initial scope within BASEMENT was developed, the "Rhone-Thur" project, has been finalized by the end of 2007. The sequel is called "Integrales Flussgebietsmanagement". It has the same co-financer as its predecessor, namely the Swiss federal office for the environment (FOEN), and basically the same participating institutions (EAWAG, WSL, LCH(EPFL) and VAW(ETHZ)). The funding runs until the end of 2011. Due to the retirement of Prof. Dr.-Ing. H.-E. Minor in summer 2008, our laboratory is solely represented in the project committee by Dr. R. Fäh at the moment.
The emphases of the new proposal for the further development of BASEMENT are advanced topics of hydraulics and sediment transport, such as secondary currents and lateral erosion. Furthermore, the efficiency of the software should be increased by the implementation of appropriate parallelisation and coupling approaches.

Since the last minor release a long time passed, which was mainly consumed by a general revision of the software. After five years of development a diligent consolidation was expedient. In addition, the coincidence of a new team member offered an unbiased reflection of the source code. All in all it was very worthwhile.
Last but not least, there are numerous bugs fixed and some new features in the current version. Mainly the efficiency of the software has been improved. The first stage of parallelisation is completed. The current implementation of the code includes the OpenMP interface which allows for parallel execution of the basic computation loops. In other words, the software is now able to exploit the power of current multi-core processors with a

convincing speedup. Furthermore, the revision of some data structures and output routines as well as the application of an optimised compiler led to a reduction in execution time.
Concerning sediment transport, the one-dimensional model BASEchain now supports the modelling of fine material, either as suspended or bed load. Also the advanced models for boundary conditions are worth mentioning. On the one hand, it is now possible to model domain boundaries with momentum and on the other hand, special boundary conditions inside the computational region, such as a weir or a gate, are implemented.
The fact, that the version 1.4 of BASEMENT is also available for the Linux operating system the first time, rounds off the new additions and features of the software package at hand.

Summarised one may say that the release 1.4 of BASEMENT is a major release due to all the different kinds of changes, but it's still a minor release concerning the new features – let's call it a "major minor" release. We are looking forward to Version 2.0 of BASEMENT, which is planned for next year.

D. Vetsch
Project Supervisor

October, 2008

Preface to Version 2.0

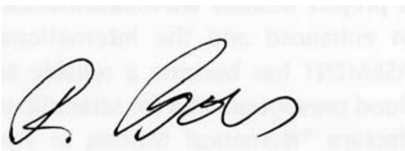
Four years ago, in spring 2006, the first version of the software system BASEMENT was completed and ready for internal use. In autumn of the same year, the first official version 1.1 of the software was released and made available as free download on the project website www.basement.ethz.ch. Since then, the functionality of the program has been enhanced and the international user community has grown gradually. Over the last years, BASEMENT has become a reliable tool for professional investigations, especially within the scope of flood prevention, and for scientific studies. Furthermore, the software is part and parcel of the lecture "Numerical Models in Hydraulic Engineering" to ensure education of young engineers in the field of hydrodynamic numerical simulation. The lecture is held on a regular basis by VAW staff for master students of civil and environmental engineering at ETH Zurich.

In February 2009, I have become the successor of Prof. em. Dr.-Ing. H.-E. Minor as Director of the Laboratory of Hydraulics, Hydrology and Glaciology (VAW) at ETH Zurich. In the meantime, I have joined the project committee "Integrales Flussgebietsmanagement"as a further representative of VAW besides Dr. R. Faeh.
Furthermore, there are some changes concerning the personnel of the project team of BASEMENT to mention. Lukas Vonwiller joined the team last autumn after having obtained his master's degree at ETH Zurich. Within the scope of his master thesis at the VAW, he studied the hydrodynamics and ecological impact of floods at the river Flaz using BASEMENT. Some of his experiences with the application of BASEMENT and selected results are documented in the new tutorial on 2-D simulations in the user manual UIV. His current duties are the application and testing of the software in terms of project work.
We were also very lucky being able to engage Dr. Ratko Veprek as a distinguished software engineer for a limited period of time. His contributions to the software, such as flow control of river systems, computational efficiency and the graphical user interface, just to name a few, are of great value. Unfortunately he will leave us by the day of the release to take on a post doctoral position abroad.

According to the announcement in the preface to version 1.4, the second major version of BASEMENT is released with little delay but with all the more important improvements and substantial new features. First of all, the new version 2.0 of the program comes with a graphical user interface (GUI), which allows running or stopping simulations and tracking the progress. Furthermore, the model setup and configuration, i.e. the assembling of the command file, is completely integrated into the GUI. The user is guided through the setup and any input is validated directly. In addition, the integrated help function, which is based on the command file reference, provides detailed information on the meaning of input parameters. This gives way to a clearer model setup compared to the rather fault-prone manual text editing, which is still available and also accessible through the GUI. Another main feature of the new GUI is the editing of the topography for BASEchain. Besides the GUI based setup, interpolation and thinning out of model cross sections, a graphical viewer helps the user to check the configuration and subdivision. For this reason, the new version

of BASEMENT comes with its own topography file format for BASEchain. The new format has a clear structure similar to the style of the command file.
Moreover, the visualisation of actual results during a simulation with BASEviz has been improved and is now more interactive, i.e. the simulation can be paused, continued or the variable shown can be switched. Other improvements concern computational efficiency and sediment transport, especially gravitational bed load transport. Please refer to the release notes in the section "introduction and installation" of this manual for further details about new features and bug fixes.

The software system BASEMENT in its current version 2.0 has reached the point to be termed as a state of the art numerical modelling tool for flow and sediment transport in rivers. The incorporated well established or new numerical approaches, software technical features like parallelization or the coupling of sub domains, advanced features for sediment transport and flow control are making it a reliable tool for professional as well as scientific applications. With the new GUI another hurdle has been cleared and a new era of the software in terms of usability has begun. We are looking forward to the further development as well as upcoming releases of BASEMENT and we are curious about how the software will establish itself in the future.



Prof. Dr. R. Boes
Committee Member of Project "Integrales Flussgebietsmanagement"
Director of VAW

May, 2010

SOFTWARE LICENSE

between

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Rämistrasse 101
8092 Zürich
Represented by Prof. Dr. Robert Boes
VAW
(Licensor)

and

Licensee

1. Definition of Software

The Software system BASEMENT is composed of the executable (binary) file BASEMENT and its documentation files (System Manuals), together herein after referred to as "Software". Not included is the source code.
Its purpose is the simulation of water flow, sediment and pollutant transport and according interaction in consideration of movable boundaries and morphological changes.

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The Visualization Toolkit (VTK)

CVM Class Library

Qt v4.6 – Cross-platform application and UI framework

Qwt - Qt Widgets for Technical Applications

BASEMENT v2.0 is based in part on the work of the Qwt project (http://qwt.sf.net).

CGNS – CFD General Notation System

cgnslib 4.5 - http://cgns.sourceforge.net

INTRODUCTION AND INSTALLATION

of ***BASEMENT***

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Table of Contents

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1 Summary of Contents

1.1 Introduction

The intention of the BASEMENT system manual is to guide and support the user in carrying out numerical simulations with BASEMENT. The documentation, in particular the introductory and theoretical chapter, shall provide a deeper insight into the implemented numerical models, their application and according preparation of necessary input data.

As a matter of fact, the application of state-of-the-art numerical models for channel flow, flood plain and natural hazard simulation is a demanding task. For this reason and despite of its incompleteness, this manual should provide helpful information to gain satisfying simulation results in terms of quality and time.

The BASEMENT system manuals are made up of three main parts – the user manual (denoted by the letter “U”), the reference manual (letter “R”) available as CD-ROM or download package. The parts, like the “Introduction and Installation” and the “Appendix and Index” are self-explaining. In the following, a short description of each main part is given.

If you are familiar with the application of numerical models as implemented in BASEMENT, the chapters “U III: Graphical User Interface”. “UIV: Tutorials” and the documentation files will be of interest to you most of all.

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1.2 Summary of the User and Reference Manual

U I – IV : USER MANUAL

The user manual mainly gives an introduction to the basic simulation environment and its application. All necessary input data and its preparation are discussed. The procedure to setup a running model and the command file, which strictly defines a scenario to be simulated, are described in detail herein.

U I : The Basic Simulation Environment

The first part of the user manual describes the basic concepts and the components of the software system BASEMENT and gives a general introduction to its application. Get into it and learn more about the meaning of “BASEchain” and “BASEplane”.

U II : Pre Processing

The careful preparation of input data, such as topographical data or a discharge hydrograph of a flood event, is crucial for the scope and the quality of the result of numerical simulations. This chapter provides basic information on how to obtain and prepare the necessary input data for the models. If you don’t understand the terms “aspect ratio” or “SMS”, this chapter is worth reading.

U III : Graphical User Interfance

After the preparation of all input data, a simulation has to be setup. By the use of a command file, all necessary simulation parameters have to be set and the input data is linked therein. The command file can be viewed and edited using a graphical user interface (GUI). This chapter explains the usage of the GUI and its features.

U IV : Tutorials

This chapter guides the user through the necessary steps to setup a numerical model up working by example. With good reason, the chosen case studies are demanding in setup and application. This part of the manual lives with your experience! The development team of BASEMENT is looking forward to enrich the tutorials section with your suggestions and practical know-how.

R I – IV : REFERENCE MANUAL

On the one hand, the reference manual covers the theoretical part of the implemented models of the software system BASEMENT. On the other hand, the detail syntax description of the input files, especially the command file, is given in this section of the manual – maybe the most important part for a proficient user of BASEMENT.

R I : Mathematical Models

The implemented models for water flow and sediment transport are either physical conservation laws, such as the shallow water or Saint Venant equations, or empirically based balance equations, all in the form of partial differential equations. This chapter shows the so-called “governing equations” which constitute the available simulation models. To correctly describe the mathematically problem, the necessary boundary conditions and source terms are given also.

R II : Numerics Kernel

Most often governing equations for flow can’t be solved analytically for general boundary conditions. For this reason, the mathematical equations have to be discretized accordingly the desired special and temporary scale of the model. This section of the manual discusses the discretization methods, mainly the finite volume method, the explicit euler scheme and especially the applied Riemann approach to solve the governing hyperbolic equation system.

R III : Test Cases

To validate the implemented numerical models and to check for their reliability, different well-known and well-documented test cases have been carried out. The models have been tested against analytical solutions and flume data. This chapter is mainly intended for experts, but also interesting for general users, who like to explore the capabilities and limits of the provided models.

Documentation files

These documentation files replace the former chapter “R IV : Command and Input Files”. These documents describe the elements of the command file, their syntax in detail and give many examples. Maybe this is the most significant part of the manual for the user at work. Herein one finds a description for each parameter and its causal arrangement. Also the formats of auxiliary files, such as hydrographs or topography files are discussed. Without a well-considered definition and arrangement of simulation parameters, the program may produce inconsistent results or even run at all.

The parameter descriptions and the examples can also be accessed via the help function in the graphical user interface (GUI) for all input tags.

2 Setup and First Start

2.1 System Requirements

2.1.1 Microsoft Windows

Release 2.0 is available for the following MS Windows systems:

- Windows 2000
- Windows XP / XP x64
- Windows Vista / Vista64
- Windows 7

Releases are only tested on Windows XP. According to reports from users of earlier releases, BASEMENT also runs on Windows 7, Windows Vista and Windows 2000.

BASEMENT needs the following programs to be installed:
- .NET Framework 3.5 Service Pack 1
- MS Visual C 2008 x86 (vcredist_x86.exe)

Both packages are freely available from Microsoft. On most machines, they are already installed because other software uses them also. For information how to get these files, please visit the FAQ on the webpage.

For the latest news concerning new features and current changes, please visit the webpage.

2.1.2 Linux

Release 2.0 is available for the following Linux systems. The binary was compiled and tested on the following:

LINUX (x86/-64):
- Ubuntu 9.10, alias “Karmic Koala”:
    - Kernel version 2.6.31-14 (SMP)
    - GNU C Library (glibc) version 2.10.1

2.1.3 Hardware Configuration

We recommend the following hardware configuration:
- single- or multi-core processors (x86/x86-64):
    - Intel (Xeon, Core 2, Pentium 4)
    - AMD (K7, K8, K10)
- RAM: 1 GB per core
- shared memory architecture

Up to this moment, BASEMENT was successfully tested on 1 to 16 core Intel and AMD computers.

2.2 Installing under Windows

2.2.1 Getting the binaries

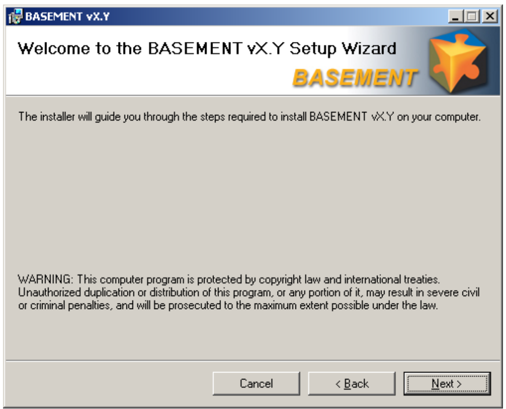
First of all, you need to get a copy of the recent software package. You can either download the most recent version from the projects webpage (http://basement.ethz.ch) free of charge or you can order the official manual as print version including a CD and a specially illustrated ring binder using the order form on the project webpage (only production costs will be charged, approx. CHF 100).

2.2.2 Installation procedure

Installation of BASEMENT from CD should start automatically if you have "autorun" enabled. Otherwise open the disk workspace and run setup.exe by double-clicking the icon. The same procedure applies, if you have downloaded the newest version from the projects webpage.

Step 1 and 2: Welcome

The splash screen of the installation opens up and shows the actual version to be installed. Click "next" to continue. The second window displays some warning about copyright protection. Click "next" to continue.

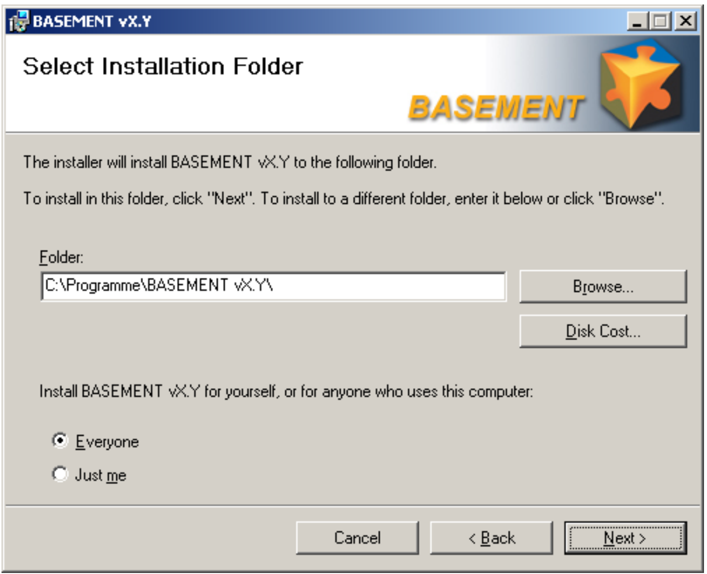


Step 3: Accepting the License Agreement

The next step is the license agreement – please read it carefully. By activating the “I agree” button, you accept the terms and conditions to use this software.

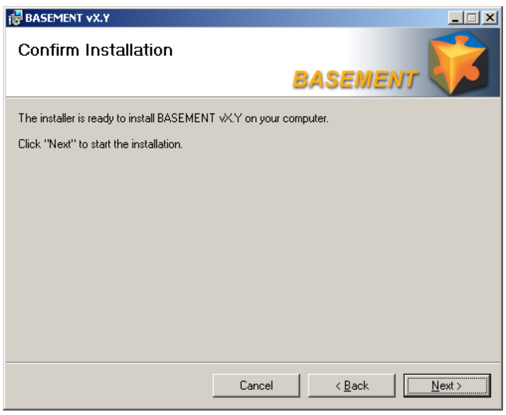
Step 4: Select the Installation Folder

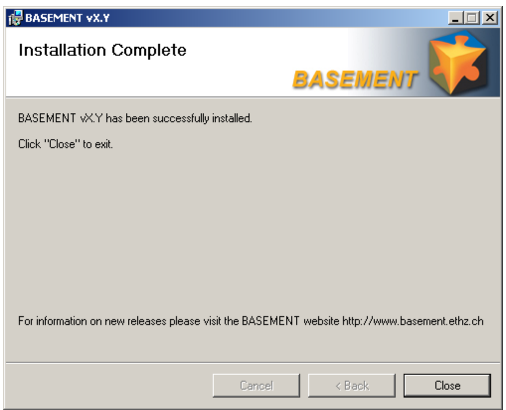
After accepting the License agreement, you can choose where to install the binaries. Default proposition is "C:\program files\BASEMENT". You are free to choose any other directory. The button "Disk costs" compares your free disk space with the required space for BASEMENT.
You can also choose whether BASEMENT is installed for all users on this machine or just for the active account. If the installation is desired for all users, you need to be logged in as administrator. When you finished your choice, click "next" to continue.



Step 5 and 6: Confirming and Finishing the Installation

This is the last chance to rethink the decision about an installation. Clicking "next" will start the installation process. After all files are copied, a final window informs about the success of the installation. Click "close" to finish the installer.





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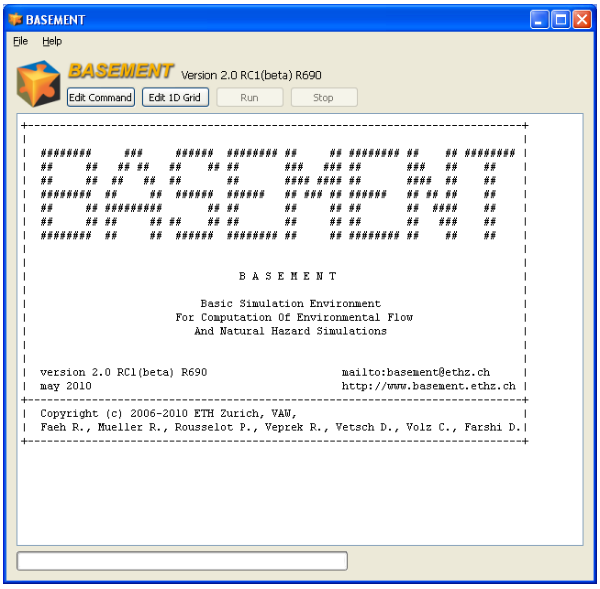
2.3 Running BASEMENT on Microsoft Windows

2.3.1 Running BASEMENT using the Graphical User Interface

After having successfully installed the program, you may notice the icon for BASEMENT on your desktop:

This is the Icon used for the program executable. The command files have a similar icon but are additionally identified by “CMD” within the logo. To get the icon for a command file displayed, the command file must end with “.bmc”.

There are two ways to start the program. Either by clicking on the program symbol or directly by double clicking a command file (File with “.bmc” ending) for BASEMENT. Since version 2.0, BASEMENT runs as a standalone application including a simple graphical user interface (to run BASEMENT in batch mode see chapter 2.3.2):

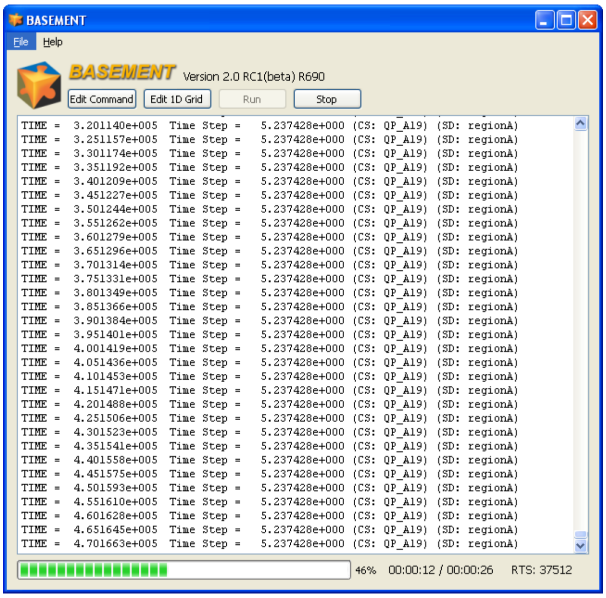


The difference between the two starting mechanisms however is simple: Starting the program by clicking the input file sets the path for the working folder and the scenarios name automatically according to the position of the input file and its content.

If you just start the program by clicking the executable, you have to select the scenario by pressing the “Edit command” button, which will open the command file editor. Using this editor, you can load (“Open File”) your command file and thereby setting the working directory to the directory where the command file is located.

Once you loaded a command file it remains the active until you load the next one or save the current one with a new name.

When a command file is available to BASEMENT, the “Run” button is enabled. Pressing it starts the simulation. The console messages of BASEMENT are printed to the console view:



Below the console, the progress of the simulation is shown, together with the elapsed time and a guess of the required overall time. At the lower right, the real time speedup (RTS) of the simulation is shown. The real time speed up gives the number of seconds calculated in the simulation within one real time second.

All files containing the results will be saved in the working directory containing the command and auxiliary files.

Further details concerning the GUI of BASEMENT are explained in the user manual UIII.

Notice:

The command filename must not contain any spaces or special characters like ä, ö, ü, è, etc.

2.3.2 Running BASEMENT on the Console

The other method to run a BASEMENT simulation is to use BASEMENT in the batch mode on the command prompt (console). The batch mode is started by calling the BASEMENT executable (BASEMENT_vX.Y.exe, whereas ‘X.Y’ has to be replaced by the actual version number) using the –b command line switch. The command line switch –b selects the batch mode and prevents the GUI to be started. The desired command file is defined using the –f command line switch.

2.4 Installing under LINUX

2.4.1 Getting the binaries

You need to get a copy of the actual distribution as described in the Windows installation section. One can either download the most recent version from the projects webpage (http://basement.ethz.ch) or one has an official manual including a CD which can be ordered on the same webpage.

2.4.2 Installation procedure

The installation of program and documentation on LINUX systems is to be done via the console. Please replace all occurrences of 'X.Y' in the installation introduction by the actual version number.

<u>Step 1</u>: Preparation of the installation

Before unzipping the zipped installation file you probably want to create a temporary directory ('/tmp') and copy the downloaded file into this directory. Change to this directory where the downloaded zip-file is located. Unzip the file by typing:

```
unzip BASEMENT_vX.Y_linux.zip
```

<u>Step 2</u>: Installation of BASEMENT and license agreement

Under the unzipped files you can find an executable named 'setup' and an 'install.txt' which has additional information on the installation process. To start the installation, run setup

```
./setup
```

and follow the instructions. The license text of BASEMENT is displayed and must be agreed on to proceed with the installation. After running setup the password protected zip-file is extracted and the debian package file is available.

<u>Step 3</u>: Installation of debian (.deb)-package*

To ease the installation of BASEMENT a debian-package is created which automatically installs all needed files, the documentation and the tutorials and test cases on the pc. To install this package administrator rights are needed. Therefore on Ubuntu the 'sudo' command is needed. To start installation type

```
sudo dpkg -i basement-X.Y-XXX.deb
```

The debian package automatically detects if your configuration misses one of the needed requirements. In such a case you can use 'apt-get install …' on Ubuntu systems to install the missing packages. Previous versions of basement are automatically detected by the installer and deleted before the installation starts.

If the installation of the package was successful, than the binary file is copied to

```
/usr/bin
```

and the program files, the documentation, the test cases and the tutorial are available under

```
/usr/share/basement
```

2.5 Running BASEMENT on LINUX

If the installation succeeded, start BASEMENT with its graphical user interface in a terminal window with a shell command prompt just by typing:

basement

Selecting an actual simulation, running a simulation on LINUX or using batch mode works the same way as it does on Windows (see chapter 2.3.1 and 2.3.2).

Notice:
The command filename must not contain any spaces or special characters like ä, ö, ü, è, etc.

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3 Release Notes

3.1 Version 1.3

Subsystem BASEdomain:

A logical error check is performed between reading the input file and the start of the simulation. In case of logical errors (contradictions, missing information), the simulation will stop immediately. In any case, a file 'inputerror.err' is created, where all errors and warnings are listed for the current simulation. It is highly recommended to have a look at this file for every simulation being started.

Subsystem BASEchain:

- problem in computation of cross section area fixed
- problem with omission of values in topography file fixed
- sediment transport fixed
- new output: difference of water volume
- new output: difference of sediment volume
- bed load formula of “Rickenmann”
- output of topology of cross section not automatic any more
- output of sediment mixtures not automatic any more

Subsystem BASEplane:

- Computation of the inlet bed load from the bed load hydrograph has been modified.
- The jacobian matrix has been corrected to calculate the slopes for the quad. Elements.
- The coefficient "C" for the weir calculation has been improved!
- The output for the cell centres is modified. For this instead of the xyz output, a mesh file including the centres coordinates with the elements number are written.
- The flux over the weir has been corrected!
- The time step computation has been also extended to the boundary edges. In the previous version only the internal edges were considered for the time step computation.
- A new parameter “node_elevation_method” has been added to the Morphology-Parameter block. The calculation of the nodal elevation based on the “node_elevation_method” can be done with interpolation or slope method.

System Manuals:

- Part UIV has a new tutorial for 2-D simulations.
- Part RIV and corresponding structures in UIV are completely revised.
- Wrong assigned page numbers in some TOCs are corrected.
- Header of part “Index / Appendix” corrected.
- **Update your hardcopy version with the documentation patch**.

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3.2 Version 1.4

General Notice:
All users working on a project with v1.3 at the moment should use v1.3 until the project ends and update for version 1.4 afterwards. Changes made to the boundary condition will lead to a slightly different behaviour of v1.4 compared to v1.3. Therefore, a calibrated scenario for v1.3 is not calibrated to work with v1.4!

Subsystem BASEparse:

- New command file structure allowing for distinction of bed load and suspended load in 1-D. The structure also changed in 2-D for similar reason.
- New structure of command file in HYDRAULICS: All friction parameters are now defined in their own block FRICTION instead of the SOURCE block as in v1.3

Attention:
The changes of the command file's structure are not backwards compatible! Input files for v1.3 will not work with v1.4 and vice versa. We recommend all users to update to version 1.4.

Subsystem BASEchain:

- problem with HQ-Relation stored in a file fixed
- problem with update of hydraulic tables after geometry change due to bed load fixed
- necessity for a comment for each cross section in HEC-RAS files eliminated
- problem with cross section names ending with one or more 0 in HEC_RAS files fixed
- beta values in Tecplot file are now mean values over the whole bed width instead of value of the first slice
- new friction type: Manning
- new binary Tecplot files for longitudinal profile data
- new binary output file for cross section topology
- new suspended load simulation
    - advection by QUICKEST scheme
    - advection by Holly-Preissmann scheme
    - advection by MDPM scheme
    - sediment exchange between water and bed
    - diffusion by given factor or internal computation

Subsystem BASEplane:

- Inner Boundary Conditions (weir and gate) implemented
- Weir Boundary Condition modified (velocity component in momentum equation)
- UCD-Output for AVS enabled (Universal Cell Data)
- additional friction types implemented (strickler, darcy, chezy, etc)
- new wall friction added to optionally consider wall friction at boundary edges
- hydrograph boundary redesigned with momentum flux at inflow (please use an external source if you want an inflow without momentum flux)
- new h-Q boundary implemented which allows the specification of a h-Q relation as outflow
- ascii and binary Tecplot output
- performance tuning of some subroutines and file outputs
- additional geometry check for ambiguous gradients
- minor bug fixes

Subsystems BASEchain and BASEplane:

- Parallelization for shared memory multi-core systems implemented
- New LINUX version prepared
- BASEviz visualization tool added (currently ONLY for Windows version)

System Manuals:

- Please read the credits and the new preface, which are introducing a new team member and are giving citation advice
- Part UI-5: new chapter about parallel processing
- Part UII-3.3: some hints concerning mesh quality, especially how to deal with ambiguous elements
- Part UIII: almost complete revision. Examples for and comments on newly added features
- Part UIV: overall correction.
- **Part RI: complete revision**
- Part RII-2.3: treatment of inner boundaries
- Part RII-3.2: schemes for suspended sediment transport
- Part RIII: additional test cases for suspended sediment transport and parallel execution
- **Part RIV: complete revision**
- **Update your hardcopy version with the documentation patch**.

3.3 Version 1.5

General:

New Features:

- Batch Mode (running BASEMENT with program arguments)

Subsystem BASEchain:

New Features:

- Source and sink of suspended load
- Conservation of sediment exchange between bed and suspended load improved

Bug fixes:

- Wrong warning concerning friction definition eliminated

Subsystem BASEplane:

New Features:

- Gate Boundary
- HLLC Riemann solver

Bug fixes:

- Value Check hQ-Relation
- Correction of Hydrograph boundary at supercritical flow conditions
- Bug fix of edges memory reservation in case of very large grids with many holes
- Vector length scaling added for the vtk velocity vector output
- Prevent output of negative flow depths

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3.4 Version 1.6

Subsystem BASEchain:

New Features:

- Implicit solution of hydrodynamics
- Smart-Jaeggi bed load formula

Bug fixes:

- Correction transport diagram
- Conveyance computation (negative areas)

Subsystem BASEplane:

New Features:

- Revision of sediment transport (Dual Mesh concept)
- Kinematic viscosity and algebraic turbulence model
- Wu bed load formula
- Improved treatment of bed source terms for quadrilateral elements
- New approach of slope calculation for quadrilateral elements
- Improved concept of wall friction treatment
- Flux correction algorithm implemented to enhance mass conservation
- New outflow boundary: ZHydrograph

Bug fixes:

- HQ-Relation and Hydrograph boundaries

System Manuals:

- Part UIII: Introduction to new features
- Part UIV: Corrections
- Part RI: Complete revision and additions, e.g. sediment transport
- Part RII: Complete revision and additions, e.g. partially wetted elements, sediment transport, dual mesh approach and implicit time integration.
- Part RIII: Additions and corrections
- Part RIV: Documentation of new features

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3.5 Version 1.7

General:

New Features:

- Coupling of subsystems BASEchain and BASEplane, i.e. sub-domains
- Flow control in river systems

Subsystem BASEchain:

New Features:

- Multiple boundaries at in- and outflow cross sections
- Speed improvements for explicit simulations
- Improvements of zhydrograph-boundary condition
- Changed behaviour of qlateral source (now uses one cross section)

Bug fixes:

- Batch execution mode corrected

Subsystem BASEplane:

New Features:

- Suspension transport 2-D
- Improvements of inner boundaries
- New procedure for updating velocities at partially dry elements (prevention of high velocities at wet-dry interfaces)
- ZHydrograph boundary condition enhanced to be used as outflow or inflow

Bug fixes:

- Correction of hydrograph boundary in case of no inflow
- Negative area for element prevented (only occurs when .2dm is manually changed so that nodes are not counter clockwise)
- Bug fixes in Tecplot output routines
- Default behaviour of HQ relation changed, partially dry edges are treated as zero_gradient instead of wall

System Manuals:

- new chapters on model coupling and flow control
- additions and corrections

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3.6 Version 2.0

General:

New Features:

- Graphical user interface (GUI) for BASEMENT with integrated reference manual. Enables faster and correct setup of command files, setup and interpolation of BASEchain topography files and running a simulation.
- Visualization (BASEviz) revised and improved to be more interactive.
- Additional Q-t-Table implemented for flow control.
- All sediment transport formulas can now be used for BASEchain and BASEplane.
- Additional bedload transport formula implemented with Meyer-Peter Müller approach for multi-grain with critical shear stress correction according to Ashida and Michiue.

Subsystem BASEparse:

- Various changes and standardizations of input tags in the command file parser.

Attention:
The changes of the command file's structure are not backwards compatible! Input files for v1.7 will not work with v2.0 and vice versa. We recommend all users to update to version 2.0.

Guidance on how to convert old command files into the new format:
There are several possibilities to update old command files. Maybe the easiest way is to use the new graphical user interface (GUI). Start the program BASEMENT and open your old command file. The message "parsing failed" will pop up and ask you to open your file in the raw editor to fix it. Confirm with the OK button. In the raw editor the parse errors will appear in the lower section in red colour. Invalid tags are pointed out and possible tags are proposed. Apply the proposed changes and click on the "Validate" button to see if your correction was successful. If some proposed tags should be unclear to you have a look at the Block List in the Reference Manual R IV. In the information-rich Block List all input blocks and possible tags are described.
Another possibility is to build up a new command file with the GUI of BASEMENT. This way you will learn to use the new GUI and will be provided with all possible input blocks, tags and information.

Subsystem BASEchain:

New Features:

- New topography format implemented for BASEchain (.bmg). Please use this file format as the default format for all new projects.
- Python-script to convert files from old Floris-format to new input format. The script can be downloaded from the website and requires 'python' to be installed (www.python.org).

- Tool in graphical user interface (GUI) for cross section interpolation.
- Tool in graphical user interface (GUI) to automatically thin out grid points and thus speed up simulations.
- Significant speed improvements especially for hydraulic calculations.
- Coupling via “off-channel” source enabled.

Bug fixes:

- Bug fix in Roe solver.

<u>Please note</u>: Due to revision works, at the moment only one soil may be specified for a cross section in morphological simulations. Usage of multiple soils will be enabled again in future.

Subsystem BASEplane:

New Features:

- New framework for data output with additional features and output variables.
- Geometric approach for gravitational bed load transport (slope failures).
- Some speed improvements for hydraulic calculations.
- Additional sediment inflow boundary condition which sets inflow to transport capacity.
- Changes in calculation of sediment fluxes. Upwind-factor now has more effect.

Bug fixes:

- H-Q iterations and default precision in Hydrograph boundary conditions fixed.
- Bug fix in treatment of fixed bed regions based on material index.
- Bug fix in deletion of layers.
- Bug fix for sediment restart.
- Error at simultaneous binary tecplot output of hydraulic and sediment data fixed.

System Manuals:

- Additions and corrections.
- Revision of hydraulic tutorial for BASEchain.
- New hydraulic and sediment tutorial for BASEplane.
- HTML-documentation files can be automatically generated by starting BASEMENT with command line flag “-doc”.

3.7 Version 2.1

General:

New Features:

- Controller extended for external sources
- Support of jpeg-output of BASEviz visualization (experimental)

Subsystem BASEchain:

New Features:

- A simple consideration of internal levees
- Time dependent grain mixtures as new upper boundary for bed load.
- Multiple soils in one cross section are possible again, a factor is available to define from which degree of submersion a soil is considered to be wetted and will be moved.
- For bed load transport the definition of the bed bottom is needed again!

Bug fixes:

- Transport diagram
- Monitoring point integration for simulations starting after time 0.
- No more elimination of elevations smaller than h dry in hydraulic balance.
- Initialisation of initial_time_step.

Subsystem BASEplane:

New Features:

- New upwind method for suspended transport
- New binary restart file format (CGNS) contains all restart data and enables restart from different solution times (hydraulics, bed load and suspension)
- Reduced mesh dependence in many situations due to changed formulation of Riemann problem on edges
- Initial depth is set to zero over the domain (and no longer to depth_min)
- Several improvements in data output (depth/wse output are consistent now, sediment balancing improved, added specific discharge, renaming of “z_bed →z_element” and “zcoord→z_node”)
- Some speed improvements for parallel execution
- Improvements and parallelization of gravitational transport

Bug fixes:

- Bugfix for inner gate because unphysical flux could be generated in dry cells
- Bed load transport rate was determined too small in some cases !
- Bugfix of 2dm mesh input. Internal edges of last nodes of the mesh could be falsely treated as boundary edges.
- Tecplot output was restricted to 6 digits, now changed to 8 digits
- Bugfix in layer interpolation on sediment elements

System Manuals:

- New manual for the graphical user interface (GUI) replaced old UIII manual
- New sediment tutorial for fractional transport for BASEplane
- Additions and corrections

4 Features of Current Version

4.1 Subsystem BASEchain

Summary of features BASEMENT v2.1 / December 2010		
	Subsystem BASEchain	
System		
	Platform	Microsoft Windos (2000, XP/XPx64, Vista/Vista-64,7), Linux (x86/-64)
	Parallelisation	Symmetric Multi-Processing (SMP), OpenMP
Numerics		
	Spatial Discretization	Finite Volumes
	Time Integration	explizit Euler, implicit Scheme (theta-method)
	Riemann Solvers	Roe
Geometry		
	Type	cross sections : simple, composite(flood plains, main channel)
	Slices	individual friction and soil description, non flow consideration
	Mobile bed	fixed bed consideration, uniform distribution of deposition and erosion over wetted part of cross section
	Input Formats	BASEMENT, Floris
Hydraulics		
	Conservative Variables	A (continuity), Q (momentum)
	Source Terms	friction (semi-implicite), bed, lateral source/sink
	Friction	Strickler (roughness kstr), Manning (roughness n), Chézy, Darcy-Weissbach, Log. friction law
	Determination of z(A)	interpolation from table, iteration,consideration of levees
	Boundary Conditions	wall, hydrograph, hQ-relation, in/out, h(t), weir, gate, multiple boundary
	Initial Conditions	sub critical backwater calculation, dry, from input file
Sediment Transport : Bed load		
	Transport Law	MPM, MPM-multi, power law, MPM-H, Parker, Rickenmann, Smart-Jaeggi, Wu, Günter 2-Grain, parametrized shear stress
	Boundary Conditions	hydrograph, upwind discharge calculation on input edge, transport capacity, fractionated hydrograph
	Active Layer	constant, variable
	Source Terms	local source/sink, dredging
Sediment Transport : Suspended load		
	Transport Equation	Advection-Diffusion Equation
	Discretization	QUICKEST, Holly-Preissmann, MDPM
	Exchange Terms	Van Rijn or Zyserman et al. / Lin
	Source Terms	local source/sink
Output Variables/Formats		
	Variables:	
	General Information	geometry and characteristics of cross sections
	Bed load	total and for each grain class
	Grain mixtures	for each cross section, slice and layer
	Formats:	
	Standard output	water surface elevation, energy level, A, Q, Froude number, C, continuity flux, momentum flux
	Tecplot Format	bed level, water surface elevation, energy level, Q, A, dike levels, bed load, grain class concentrations of active layer and suspended sediment concentration
	Monitoring Output	A, Q, Qb, WSE, V, geometry
	Restart files	hydrodynamics, bedload, suspended load
	Integral Qantities	Variation of water volume, variation of sediment volume, suspended sediment volume

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4.2 Subsystem BASEplane

Summary of features
BASEMENT v2.1 / December 2010

Subsystem BASEplane

System		
	Platform	Microsoft Windos (2000, XP/XP x64, Vista/Vista-64, 7), Linux (x86/-64)
	Parallelisation	Symmetric Multi-Processing (SMP), OpenMP
Numerics		
	Spatial Discretization	Finite Volumes
	Time Integration	explicit Euler
	Riemann Solvers	exact, HLL, HLLC
Geometry		
	Cell/Grid Types	triangular, quadrilateral, hybrid
	Mobile bed	fixed bed consideration, bed armor consideration, uniform distribution of deposition and erosion over wet elements
	Input Formats	SMS Grid
Hydraulics		
	Conservative Variables	h, u.h, v.h
	Source Terms	friction, bed slope, local discharge source/sink, diffusive fluxes (kinematic and turbulent viscosity)
	Friction	Strickler (roughness kstr), Manning (roughness n), Chézy, Darcy-Weissbach, Log. friction law
	Boundary Conditions	wall, inlet (hydrograph), outlet (weir, gate, zero gradient, h-Q relation, zHydrograph), inner boundaries (inner weir, inner gate)
	Initial Conditions	dry, user defined condition (based on material index) , continuning old simulation
Sediment Transport : Bed load		
	Transport Law	MPM, MPM-multi, MPM-H, Parker, Rickenmann, Smart & Jaeggi, Wu, Günter 2-Grain, parametrized shear stress, Gravitational transport due to bank failure
	Boundary Conditions	wall, inlet(hydrograph, transport capacity), outlet(outflow = inflow)
	Active Layer	constant, variable thickness
	Source Terms	local bed load source/sink
Sediment Transport : Suspended load		
	Transport Equation	Advection-Diffusion Equation
	Discretization	MDPM, Upwind-Scheme
	Exchange Terms	Van Rijn or Zyserman et al. / Lin
	Source Terms	local source/sink
Sediment Transport : Gravitational induced transport		
	Approach	Geometrical modelling based on critical failure angles
	Features	unstructured mesh, single and multiple grain classes
Output Variables/Formats		
	Variables:	
	General Information	Input file, element data (water depth, velocities, bed shear stress, etc.), node data (bed elevation, etc.), Balances
	Bed load	element data(theta_critical, etc.), node data (bedload, delta_z, etc.)
	Grain mixtures	grains size distribution for selected elements
	Formats:	
	Standard output	SMS Format and ASCII tables
	Monitoring Output	String discharge, Boundaries, Balances
	Time History	time history of selected elements, nodes or edges
	Additional Formats	Tecplot, AVS-UCD
	Restart file	binary format (CGNS), hydraulic computation, bed oad computation, suspended load computation

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APPENDIX AND INDEX

of BASEMENT

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Table of Contents

A. Notation

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A. Notation

A.1. Super- and Subscripts

$(.)_B$	Property of top most soil layer for bed load (active layer)
$(.)_{cr}$	Critical value
$(.)_i$, $(.)_j$, $(.)_k$	Index corresponding to three dimensional Cartesian coordinate system $\mathbb{R}^3$ with coordinates (x, y, z)
$(.)_g$	Property corresponding to g^{th} grain size class
$(.)_L$	Property on the left hand side
$(.)_l$	Lateral property
$(.)^n$	n^{th} step of time integration
$(.)_R$	Property on the right hand side
$(.)_S$	Property at water surface
$(.)_{Sub}$	Property of bed material storage layer (sub layer)
$(.)_x$, $(.)_y$, $(.)_z$	Property corresponding to three dimensional Cartesian coordinate system $\mathbb{R}^3$ with coordinates (x, y, z)
$(.)_{(.),(.)}$	Dual property, i.e. $Q_{B,x}$ = bed load discharge in x direction
$(.)_{(.)_{(.)},(.)}$	Triple property, i.e. $Q_{B_g,x}$ = bed load discharge of grain size class g in x direction

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A.2. Differential Operators

$\frac{\mathrm{d}}{\mathrm{d}x}$	Differential operator for derivation with respect to variable x
$\frac{\mathrm{d}^n}{\mathrm{d}x^n}$	Differential operator for derivation of order n w. r. to var. x
$\frac{\partial}{\partial x}$	Partial differential operator for derivation w. r. to variable x
$\frac{\partial^n}{\partial x^n}$	Partial differential operator for derivation of order n w. r. to var. x
∇	Nabla operator. In three-dimensional Cartesian coordinate system $\mathbb{R}^3$ with coordinates (x, y, z): $\nabla = \left(\frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z}\right)^T$

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A.3. English Symbols

Symbol	*Unit*	*Definition*
A	[m²]	Wetted cross section area
$\mathbf{a}$	[m/s²]	Acceleration
A_{red}	[m²]	Reduced area
c	[m/s]	Wave speed
c_f	[-]	Friction coefficient
C	[-]	Concentration
c_μ	[-]	Dimensionless coefficient (used for turb. kin. viscosity)
d_g	[m]	Mean grain size of the size class g
d_m	[m]	Arithmetic mean grain size according to Meyer-Peter & Müller
$\mathbf{F}(\mathbf{U}),\mathbf{G}(\mathbf{U})$	[-]	Flux vectors
$\mathbf{F}$	[N]	Force
$\mathbf{g}$	[m/s²]	Gravity
h	[m]	Water depth, flow depth
h_B	[m]	Thickness of active layer
K	[m³/s]	Conveyance factor $K = k_{st} A R^{2/3}$
k_{st}	[m^1/3/s]	Strickler factor
k_s	[mm]	equivalent roughness height
m	[kg]	Mass
$\mathbf{n}$	[m/s]	Normal (directed outward) unit flow vector of a computational cell
ng	[-]	Total number of grain size classes
M	[Ns]	Momentum
P	[N/m²]	Pressure
P	[m]	Hydraulic Perimeter
p	[-]	Porosity
p_B	[-]	Porosity of bed material in active layer
p_{Sub}	[-]	Porosity of bed material in sub layer
Q	[m³/s]	Stream- or surface discharge
Q_B	[m³/s]	total bed load flux for cross section
q_{B_g}	[m³/s/m]	total bed load flux of grain size class g per unit width
$q_{B_g,x}$, $q_{B_g,y}$	[m³/s/m]	Cartesian components of total bed load flux q_{B_g}
$q_{B_g,xx}$, $q_{B_g,yy}$	[m³/s/m]	Cartesian comp. of bed load flux due to stream forces
$q_{B_g,xy}$, $q_{B_g,yx}$	[m³/s/m]	Cartesian comp. of lateral bed load flux
q_l	[m²/s]	Specific lateral discharge (discharge per meter of length)
R	[m]	Hydraulic radius
$\mathbf{S}(\mathbf{U})$	[-]	Vector of source terms
S_f	[-]	Friction slope
S_B	[-]	Bed slope
S_g	[m/s]	suspended load source per cell and grain size class
Sf_g	[m/s]	active layer floor source per cell and grain size class

Sl_g	[m/s]	local sediment source per cell and grain size class
t	[s]	Time
$\mathbf{U}$	[-]	Vector of conserved variables
$\mathbf{u}$	[m/s]	Flow velocity vector with Cartesian components (u, v, w)
u_*	[m/s]	shear stress veleocity
u, v, w	[m/s]	Cartesian components of flow velocity vector $\mathbf{u}$
$\overline{u}, \overline{v}$	[m/s]	Cartesian components of depth averaged flow velocity
u_B, v_B, w_B	[m/s]	Cartesian components of flow velocity at bottom
u_S, v_S, w_S	[m/s]	Cartesian components of flow velocity at water surface
V	[m^3]	Volume
x,y,z	[-]	Cartesian coordinate axes
x, y, z	[m]	Distance in corresponding Cartesian direction
z_B	[m]	Bottom elevation
z_S	[m]	Water surface elevation
z_F	[m]	Elevation of active layer floor

A.4. Greek Symbols

Symbol	*Unit*	*Definition*
α_B	[-]	Empirical parameter depending on the dimensionless Shear stress of the mixture
β_g	[-]	volumetric fraction of grain size class g in active layer
$\beta_{g,Sub}$	[-]	volumetric fraction of grain size class g in active layer
Γ	[-]	Eddy diffusivity
κ	[-]	Kármán constant
Δt	[s]	Computational time step
Δt_h	[s]	Time step for hydraulic sequence
Δt_s	[s]	Time step for sediment transport sequence
Δt_{seq}	[s]	Overall, sequential time step
$\Delta x, \Delta y, \Delta z$	[m]	Grid spacing according to three dimensional Cartesian Coordinate system $\mathbb{R}^3$ with coordinates (x, y, z)
η	[kg/ms]	Molecular viscosity
ν	[m²/s]	Kinematic viscosity, μ/ρ
ν_ε	[m²/s]	Isotropic eddy viscosity
ν_t	[m²/s]	Turbulent kinematic viscosity $\nu_t = \nu_0 + c_\mu u^* h$
ν_0	[m²/s]	Base kinematics eddy viscosity
ρ	[kg/m³]	Mass density (fluid)
ρ_s	[kg/m³]	Bed material density
$\tau_{B,x}, \tau_{B,y}$	[N/m²]	Cartesian components of bottom shear stress vector
$\boldsymbol{\tau}_B$	[N/m²]	Vector of shear stress at bottom due to water flow
$\tau_{B_g,crit}$	[N/m²]	Critical shear stress related to grain size d_g
$\tau_{S,x}, \tau_{S,y}$	[N/m²]	Cartesian components of surface shear stress vector
$\boldsymbol{\tau}_S$	[N/m²]	Vector of shear stress at water surface (e.g. due to wind)
Ω	[m²]	Area of an element
ξ_g	[-]	Hiding factor

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